NASA Innovative Advanced Concepts

Economical Radioisotope Power

Completed Technology Project (2011 - 2012)

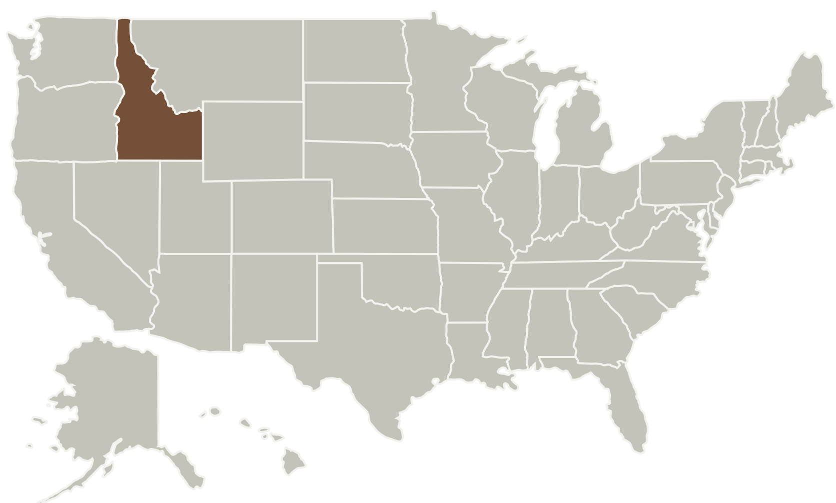
Project Introduction

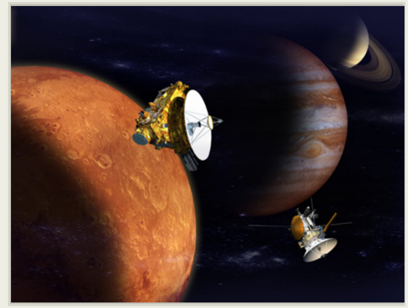
Almost all robotic space exploration missions and all Apollo missions to the moon used Radioisotopic Thermoelectric Generators (RTGs) to provide electrical power to instruments. The RTGs rely on the conversion of the heat produced by the radioactive decay of an isotope of plutonium (Pu-238) to electricity. Unfortunately, the supply of Pu-238 is about to run out. Developing a reliable supply of Pu-238 is crucial to almost all future space missions. We propose to investigate an economical production method for Pu-238 that will allow NASA or a private venture to produce several kilograms per year without the need for large government investment. The Center for Space Nuclear Research will evaluate the production rate in a commercial nuclear reactor, optimize the transit times of the target material in the reactor, assess costs of facilities to produce the isotopes, and estimate any costs to handle the waste stream from the process.

Anticipated Benefits

Developing a reliable supply of Pu-238 is crucial to almost all future space missions.

Primary U.S. Work Locations and Key Partners





Project Image Economical Radioisotope Power

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Organizations Performing Work	Role	Type	Location
Center for Space Nuclear Research	Lead Organization	Industry	
Universities Space Research Association(USRA)	Supporting Organization	R&D Center	Huntsville, Alabama
University of Utah	Supporting Organization	Academia	Salt Lake City, Utah

Primary U.S. Work Locations
Idaho

Project Transitions

September 2011: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Center for Space Nuclear Research

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

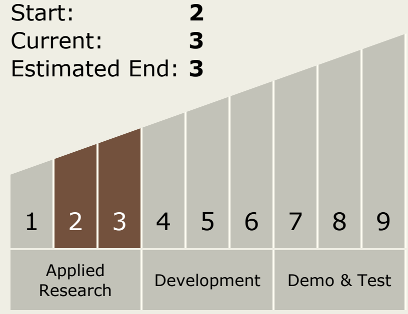
Eric A Eberly

Principal Investigator:

Steven Howe

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



September 2012: Closed out

Closeout Summary: In the Phase I NIAC grant, the CSNR has evaluated the fe asibility of using a low power, commercially available nuclear reactor to produce 1.5 kg of Pu-238 per year. The impact on the neutronics of the reactor have bee n assessed, the amount of Neptunium target material estimated, and the produc tion rates calculated. In addition, the size of the post-irradiation processing facili ty has been established. Finally, as the study progressed, a new method for fabr icating the Pu-238 product into the form used for power sources has been identi fied to reduce the cost of the final product. In short, the concept appears to be v iable, can produce the amount of Pu-238 needed to support the NASA missions, can be available within a few years, and will cost significantly less than the curre nt DOE program. The alternative method to produce Pu-238 is to continuously fl ow an encapsulated aqueous solution containing a high concentration of dissolve d Np-237 in a water carrier stream. Once the optimum irradiation period is com pleted, the encapsulated target slowly moves through the reactor's water tank w hich allows for time for the decay of Np-238 to Pu-238. This process allows smal l quantities of Pu-238 to be processed on a weekly basis so that a much smaller, and less costly, facility is needed to accumulate the Pu-238. One other aspect th at has come out of the Phase I effort is the recognition that the new process will produce a substantially smaller waste stream of radioactive acidic solution, mixe d waste, which has to be stored or processed. Thus, the method will produce su bstantially reduced costs. In addition to the technical assessment of the producti on, the study sought to determine the answers to two major issues: 1) given a s ufficient price per kg of Pu-238, could a sufficient return on investment (ROI) be possible so that private venture would pay the up-front capital costs saving the government this requirement in times of diminished budgets, and 2) is it more c ost effective to install the new reactor on private land with private operations rat her than locating the reactor at a DOE facility? The results of the study indicate t hat a 20% ROI is possible if the price per kg paid for the material is commensur ate with the last known, circa 2007, asking price from Russia. The results also s how that, due to lower security and transportation costs, the only responsible op tion is to locate the reactor at the Idaho National Laboratory site of the DOE. Th e Phase I effort utilized experimentally measured neutron spectra from a 1 MW TRIGA reactor at the Kansas State University to estimate the Pu-238 production. Although several reactor types may be available for Pu-238 production, the TRI GA was used to model the production rates due to the large database regarding neutron flux and costs. By assuming a linear scaling of the neutron flux but keep ing the neutron spectra the same, the production rate of the Pu-238, the concen tration of Pu-236, and the amount of fission products could be calculated. The c alculations show that an irradiation time of between 15 to 18 days with a 12 day decay time is optimum. Pu-236 contamination should be less than 2 ppm. The a mount of fission products is estimated to be 150 gms/yr. Using an 18 day irradi ation time, the production rate versus neutron flux, i.e. reactor power, was dete rmined. The trade studies indicate that a reactor at 3.8 or 10 MW can produce 1.5 or 6.25 kgs/yr of Pu-238 respectively. If a 20% return on investment is requ ired, i.e. if the facility is privately funded, the price of the Pu-238 sold to the DO E would have to be 10 $M/kg and 4.3 $M/kg respectively. If no ROI is required, i.e. the US government funds the facility, then the price is 4.9 $M/kg and 1.6 $M/kg for the 1.5 kg and the 6.25 kg respectively. In either case, the results of this study indicate that the 1.5 kgs/yr of Pu-238 can be produced in a new facilit y within a 3-4 year timeframe for around $50M and return a 20 % ROI to an inv estor group.

Technology Areas

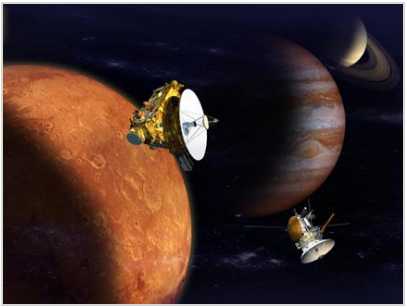
Primary:

- TX01 Propulsion Systems
  - └─ TX01.4 Advanced Propulsion
    - └─ TX01.4.3 Nuclear Thermal Propulsion

Target Destination

Mars

Images



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(https://techport.nasa.gov/image/102245)